Artificial Intelligence: The Impact on the Transportation Industry

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by

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Abstract

Since the creation of what would become the semi-truck in 1898 by Alexander Winton, the transportation industry has evolved in many ways. The concept of the semi-truck has changed over the years from being a simple hauling machine that could only haul a single car at a time, to a powerhouse of a vehicle that can haul upwards of 80,000 pounds. Ever-changing infrastructure and roadways in addition to the ever-growing need for the transportation of consumer and commercial goods helped give way to the semi-trucks that travel the highways of the world today. The innovations of the future do not come without a price though. Every year in the United States roughly 4,000 people are killed as the result of a crash involving a large truck, roughly 115,000 people are injured in similar crashes, and billions of dollars are paid out in legal settlement. The artificial automation of transportation vehicles seeks to lessen and even eliminate the injury and death that occur every year while also saving logistics companies money on legal fees, wages, and fuel. The research collected in this thesis explores the history of the semi-truck from its inception to today and discusses the impact that artificial intelligence in the realm of self-driving vehicles imposes on the transportation industry.

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I would like to thank Dr. Catherine Chen for advising me through this project. Her help during this process has been only a small part of the guidance that I have received over the past four years.

Process Analysis Statement

Artificial intelligence has always been something of great interest to me and I chose to research this topic as it relates to the automation of the transportation and logistics industry because I wanted to explore the innovations and discoveries being made as well as study the potential positive and negative effects this innovation poses for the industry. Research was mainly conducted by studying past and present data detailing crash records of the past 10 years and the financial impact these crashes caused. Injury and death rates resulting from accidents involving large trucks in the United States as well as the European Union were also analyzed to discover the impact that these crashes had upon the victims. Artificial intelligence has been growing and developing at an incredible rate and many companies are seeking to revolutionize the world in many different ways. I conducted research into a few of the companies that are specifically trying to change how the transportation industry works with the introduction of automated driving systems. It is fascinating how these driving systems, controlled solely by a number of sensors and lines of computer code, can revolutionize the way the world drives and the way an entire industry works. Though these systems are not as simple as they may seem, constant research and development are being conducted that could one day become the norm in how society operates. I took this research one step further and analyzed how this technology has the potential to change the transportation industry. With the automation of delivery vehicles and large trucks, labor costs, fuel costs, and expenses from lawsuits and settlements can potentially be lowered or avoided by logistics companies, and the risk of injury and death from roadway accidents can be mitigated by smarter driving systems. Human error poses the largest threat to drivers on the road today, and the automation of driving systems seeks to eliminate that risk. I wanted to research the innovations being made using this technology not only because it has the potential to save lives, but also because of the impact the transportation industry could experience. This thesis is the result of that research.

The History of the Semi-Truck

In the year 1898, a man by the name of Alexander Winton invented and produced what was to become the very first semi-truck (Magoci 2017). Winton was, by trade, an early automobile manufacturer. His company produced and sold automobiles out of their plant in Cleveland, Ohio and once the company began selling, Winton found a roadblock in his way; he had no way of transporting these automobiles to their respective buyers. The only way that he had at his disposal was to personally drive the vehicle all the way to the person who bought it, incurring any wear and tear upon the vehicle along the way. Delivery would also be quite expensive and he was worried that none of his customers would be willing to pay this fee. Winton needed a way to avoid unnecessary wear and tear on his automobiles during transport, and he also realized that he would need a way to return to the plant once he or one of his workers had delivered the vehicle. Later in the year in 1898, Winton began developing a concept for a vehicle that could haul his automobiles long distances to his customers. Simply put, he named his invention the Automobile Hauler to serve that singular purpose.

The very next year, Winton's manufacturing company began production of the automobile hauler, so they could begin delivering their vehicles to customers around the country. They even began producing automobile haulers to sell to other companies who were also facing the same issues as Winton was. The automobile hauler was a very simply designed vehicle that consisted of a modified car, capable of pulling more weight behind it than a standard car, and a large cart hooked to the back. Winton's invention, though it was only capable of hauling one automobile at a time, became the standard for early delivery trucks and started other companies on the road to create their own delivery trucks that would one day become the semi-trucks that travel the roads today.

While the early semi-truck may have been created and produced by the needs of the auto manufacturing industry, another key industry helped to evolve the concept of the semi-truck to more closely resemble their modern counterparts. In the 1930s, the logging industry of the Pacific Northwest was faced with the task of finding a way to haul more lumber from a job site to the lumber mills in order to save time and meet customer demand. Early transport vehicles were extremely limited in the amount of cargo they could haul from point A to point B, and these logging companies needed a better way to do just that. A truck manufacturing company called Peterbilt stepped in to help serve the demand coming from these West Coast loggers (Peterbilt). Peterbilt refurbished old army supply trucks effectively increasing the amount of weight they could haul. In addition, Peterbilt created heavy-duty trailers that could hold more weight than their predecessors and were specifically designed to transport cut lumber. Peterbilt's innovation didn't stop with their model 260 and 334 logging trucks as they have gone on to be one of the prominent leaders in the large truck manufacturing industry today.

From its humble beginnings in a manufacturing plant in Cleveland, Ohio, Alexander Winton's automobile hauler became something more than it was originally designed for. Peterbilt and many other companies transformed the automobile hauler into a more advanced vehicle capable of transporting more than one vehicle and even freshly cut timber. Trailers also began being designed in order to transport perishable goods like meat and vegetables. As the population of America and the demand for more goods to be transported continued to grow throughout the 20th century, companies had to continually innovate and find new and better ways to transport goods. These innovations would eventually culminate with the semi-trucks that travel our roads today. Semi-trucks have evolved from vehicles that could only carry roughly 2,500 pounds to enormous hauling machines capable of transporting upwards of 400 tons. The innovations made over the past century have helped to serve one of the most important industries in the world, but these advancements did not come without a price.

The Impact of the Semi-Truck

It is without question that the invention of the semi-truck helped to revolutionize the way that goods were transported throughout the world. But as the innovations continued and semi-trucks became capable of hauling more weight, they also became more dangerous as their size increased. Even the early versions of the semi-truck were dangerous for their time as they were larger than most other vehicles that existed on roadways at the time. Today, semi-truck cabs can weigh anywhere between 10,000-20,000 pounds, and are legally allowed to reach a maximum weight of 80,000 pounds including the trailer (Barradas). In comparison, the average weight of a passenger vehicle is roughly 5,000 pounds, anywhere between ¼ and ½ as heavy as a semi-truck cab, and potentially 37 tons lighter than a semi-truck with a full trailer. As semi-trucks have become more dangerous as time progresses; more crashes involving large trucks are occurring every year.

According to the National Highway Traffic Safety Administration, an estimated 433,000 police reported crashes involving a semi-truck occurred in 2015 (NHTSA). Crashes involving semi-trucks are known to be high-damage crashes often resulting in some sort of injury, generally to the occupant of a passenger vehicle, and in a number of cases, also result in death. Out of the 433,000 reported crashes in 2015, 116,000 vehicle occupants were injured. To break these number down even further, of the 116,000 reported injuries, roughly 84,000 (73%) were sustained by occupants of passenger vehicles, 30,000 (24%) were sustained by occupants of large semi-trucks, and another 3,000 (4%) were classified as non-occupant cyclist or pedestrians. In comparison, almost 1,000 more fatal crashes occurred in the year 2006 but nearly 10,000 less injuries were reported. Injury and fatality rates began decreasing between 2006 and 2009, but have steadily been on the rise since. *Table 1* details the number of injuries resulting from a crash involving a large truck and related occupant specific data. 2016 injury data has not yet been reported to the NHTSA.

Table 1: Injury Data for Crashes Involving Large Trucks, 2006-2016

Year	Truck Occupants Injured	Other Vehicle Occupants Injured	Non-occupants Injured	Total Reported Injuries	Percent Increase/Decrease From Previous Year
2006	23,000	81,000	2,000	106,000	N/A
2007	23,000	75,000	2,000	101,000	(4.72)%
2008	23,000	64,000	3,000	90,000	(10.89)%
2009	17,000	56,000	1,000	74,000	(17.78)%
2010	20,000	58,000	2,000	80,000	8.11%
2011	23,000	64,000	2,000	89,000	11.25%
2012	25,000	76,000	3,000	104,000	16.85%
2013	24,000	69,000	2,000	95,000	(8.65)%
2014	27,000	82,000	2,000	111,000	16.84%
2015	30,000	84,000	3,000	116,000	4.5%
2016	N/A	N/A	N/A	N/A	N/A

Source: National Highway Traffic Safety Administration

In addition to this data, other findings include that the percentage of drivers injured is slowly shifting from occupants of other vehicle and non-occupants, to the occupants of large trucks. According to the NHTSA's findings, while occupants of other vehicles and those classified as non-occupants accounted for roughly 75% of all reported injuries in 2015, this number has decreased from the low 80's reported earlier in the decade. As injury rates slowly begin to rise, fatality rates have also been observed rising since 2009. *Table 2* shows the number of fatalities resulting from a crash involving a large truck and related occupant specific data.

Table 2: Fatality Data for Crashes Involving Large Trucks

Year	Truck Occupants Killed	Other Vehicle Occupants Killed	Non-occupants killed	Total Fatalities	Percent Increase/Decrease From Previous Year
2006	805	3,797	425	5,027	N/A
2007	805	3,608	409	4,822	(4.08)%
2008	682	3,151	412	4,245	(11.97)%
2009	499	2,558	323	3,380	(20.38)%
2010	530	2,797	359	3,686	9.05%
2011	640	2,713	428	3,781	2.58%
2012	697	2,857	390	3,944	4.31%
2013	695	2,845	441	3,981	0.94%
2014	656	2,859	393	3,908	(1.83)%
2015	665	3,015	414	4,094	4.76
2016	722	3,127	468	4,317	5.44

Source: National Highway Traffic Safety Administration

As shown in *Table 2*, there were quite significant decreases in the number of fatalities from the previous years in 2008 and 2009, but since, the number of fatalities has slowly been rising. The European Union also experiences issues with large truck accidents, but the EU has slowly started to become safer for all drivers. *Table 3* below shows fatality data for crashes involving large trucks between 2005 and 2014. Heavy goods vehicle is the term used in the European Union to refer to a large truck that transports goods. Vehicle occupant data was not provided.

Table 3: EU Fatality Data for Crashes Involving Heavy Goods Vehicles, 2005-2014

Year	Fatalities From Crashes Involving Heavy Goods Vehicles	Percent Increase/Decrease From Previous Year
2005	7,609	N/A
2006	7,233	(4.9)%
2007	6,851	(5.3)%
2008	6,245	(8.8)%
2009	5,046	(19.2)%
2010	4,586	(9.1)%
2011	4,490	(2.1)%
2012	4,211	(6.2)%
2013	3,945	(6.3)%
2014	3,863	(2.1)%

Sources: The European Commission and the European Road Safety Observatory

The European Union has experienced a decrease in the number of fatal accidents involving heavy goods vehicles over the past decade. As shown in *Table 3*, the death toll fell from just over 7,600 people in 2005 to under 3,900 in 2014, a 49.23% overall decrease. While the European Union is experiencing significant decreases in the number of fatal accidents, the United States is seeing a slight increase on a year-by-year basis.

In the United States, even though there were 700 fewer deaths resulting from a crash involving a large truck in 2016 than 2006, since the low point reported in 2009, there has been a 27.72% increase in the number of fatal accidents. The number of police reported injuries has also risen by 56.76% (increased from 74,000 to 116,000) since 2009 and have the potential to be even higher once the 2016 injury data has been reported and documented. Comprehensive charts detailing all the data from which these table have been derived can be found in Appendix A.

The Impact on Logistics Companies

Logistics companies around the world rely on the use of large trucks and heavy-goods vehicles to deliver goods to their final destinations. In the United States alone, as of 2017, there were a reported 3.5 million registered truck drivers working at over 1.5 million companies around the country (American Trucking Association and the U.S. Department of Transportation). Logistics companies incur the risks associated with driving large trucks and are tasked with training and monitoring employees to make sure that safety is always a number-one priority. These companies look to avoid crashes that can result in lost time, damaged goods, injuries, settlement fees and lawsuits, and even death. The Federal Motor Carrier Safety Administration (2005) reported average costs per large truck crash in categories such as reported medical costs, property damage, lost productivity from traffic delays, and the total average cost per crash based on injury severity. *Table 4* details the FMCSA's findings.

Table 4: Average Costs Associated with Large Truck Crashes by Injury Severity

Reported Injury Severity	Average Medical Costs	Average Emergency Services Costs	Average Property Damage Costs	Total Monetized Lost Productivity	Average Total Cost per Victim
No Injury	$719	$46	$6,673	$2,884	$11,339
Possible Injury	$6,748	$164	$17,877	$28,666	$85,164
Non-incapacitating Injury	$12,701	$163	$21,713	$50,364	$129,573
Incapacitating Injury	$92,651	$445	$26,294	$279,210	$783,017
Death	$30,916	$989	$66,336	$916,141	$3,098,241

Source: Federal Motor Carrier Safety Administration (2005)

These reported averages did not include potential lawsuits and legal settlements paid out by trucking companies. When a lawsuit is filed, both the driver of the truck responsible for the accident and the trucking company that driver works for are faced with the suit. Christopher Simon, a Georgia Attorney at Law, details the results of many cases brought before the court in Georgia. Settlements in these cases ranged from a $27,000 settlement for medical bill expenses, a $54,000 settlement to cover physical therapy bills, and an $85,000 settlement to cover physical therapy bills and the cost of an orthopedist (Simon). In addition, the FMCSA reports that the average total cost of a fatal crash involving a medium/heavy truck can total over $7 million (FMCSA). On top of property damage, medical and emergency services, and lost productivity costs, the cost of a legal settlements in a fatal crash can range anywhere between $3-$4 million. A reported lawsuit involving one of the country's largest transportation companies, Swift Transportation, involved a $12 million settlement being reached after a Swift driver left a passenger of a rental car almost completely paralyzed from the neck down (Duffy).

Trucking companies are involved in crashes and lawsuits every year. Research was done into the top 10 largest logistics and transportation companies in the United States, and the number of reported crashes each was involved in as well as the number of suits filed against the company between 2004 and 2018. Data was pulled and analyzed from the Federal Motor Carrier Safety Administration Safety Measurement System database and from the Justia Dockets & Filings database. *Table 5* includes crash data reported over the last 24 months from the 10 largest logistics and transportation companies in the United States with the addition of FedEx and the United Parcel Service (UPS). The total number of motor vehicle lawsuits filed against each company is also provided for the years 2004-2018. The average severity weight, as described by the FMCSA, indicates the severity of each reported crash. Weights between 1 and 2 indicate a crash involving a tow-away but no reported injury or fatality. Weights above 2 indicate a crash resulting in a reported injury or fatality. Appendix B contains bar charts depicting crash data per carrier.

Table 5: Crash Statistics by Major Logistics Providers

Logistics Company	Total Crashes Since April 2016	Average Number of Crashes per Month	Average Severity Weight of Crashes	Total Number of Reported Lawsuits Filed Since 2004
Swift Transportation	2,260	94	1.33	299
Schneider Intl.	1,023	43	1.35	154
JB Hunt	1,313	55	1.36	11
Landstar	411	17	1.35	10
Werner Enterprises	1001	42	1.32	289
Prime	740	31	1.32	86
US Xpress	797	33	1.35	16
CRST	381	16	1.34	19
Crete	507	21	1.30	14
Knight Transportation	323	13	1.30	56
FedEx	1,805	75	1.34	6
United Parcel Service (UPS)	2,016	84	1.37	28
Total of Top 10:	**9,116**	**365**	**1.33**	**1,050**
Total of Top 10 Including FedEx and UPS:	**12,937**	**524**	**1.34**	**1,084**

Sources: Federal Motor Carrier Safety Administration Safety Measurement System and Justia Dockets & Filings Database

Over the last 24 months, the top 10 transportation companies have been involved in over 9,000 police reported crashes and with the addition of FedEx and UPS, that number is nearly 13,000. While many of these crashes have been assigned with a severity rate below 2, vehicle tow-away still costs transportation companies time and money from lost productivity, potential asset damage, and even potential damage to the goods being transported. In addition to these costs, companies are paying out thousands if not millions of dollars every year in settlement costs. The reported lawsuit data does not include settlements that were made before lawsuits were filed, so the amount of money companies are spending every year as the result of crashes could be significantly higher.

Artificial Intelligence and Automation

Innovations being made in the area of artificial intelligence specifically relating to vehicular automation seek to help decrease the amount of crashes that occur each year and seek to increase carrier efficiency and save money in the long run. In order to understand how autonomy relates to vehicular automation, one must first understand the stages of automation. The National Highway Traffic Safety Administration defines the following 6 stages of automation:

- **Automation Level 0:** No Autonomy. The driver performs all functions and driving tasks with no assistance from the vehicle.
- **Automation Level 1:** Driver Assistance. Vehicle is controlled by the driver, but some driving assist features may assist in certain functions and driving tasks. Driving assist features can include adaptive cruise control.
- **Automation Level 2:** Partial Automation. Vehicle has combined automated features, but the driver must remain alert and engaged to perform driving tasks and monitor the environment. Combined automated features can include lane keep assist and autopilot functions.
- **Automation Level 3:** Conditional Automation. A driver is still necessary to perform driving tasks, but is not required to monitor the environment. The driver must remain alert and engaged to be ready to take control of the vehicle at any given time.

- **Automation Level 4:** High Automation. The vehicle is capable of performing all driving function under certain circumstances and environmental conditions. The driver may have the option to take control of the vehicle.
- **Automation Level 5:** Full Automation. The vehicle is capable of performing all driving duties under all given circumstances and environmental conditions. The driver may have the option to take control of the vehicle.

Many of the vehicles being driven today may have some form of automated features that the driver may not even realize are automated. Some early form of automation developed between 2000 and 2010 include Blind Spot Detection, Lane Departure Warning, and Stability Controls. Innovations have continued over the past decade and more automated features such as Lane Keep Assist, Automatic Emergency Breaking systems, Self-Parking, and Adaptive Cruise Control have found their way into vehicles every year. The National Highway Traffic Safety Administration projects that by the year 2025, full automation and highway autopilot may become the standard for all vehicles.

Companies Focused on Self-driving Technologies

As advancements are being made in the realm of automation, many companies have been researching and developing automated driving systems to help streamline their business. In 2016, Uber, a company that specializes in what is known as "peer-to-peer ridesharing" (Uber), transformed an old steel mill outside of Pittsburgh, Pennsylvania into a testing site for self-driving technology. Almono, as the fake city is called, provides Uber with the opportunity to test their self-driving technology in a simulated environment. Almono was built to simulate roadway condition and includes roundabouts, traffic signals, and even mannequin pedestrians that roam around the city as obstacles for the cars. Uber has also included large shipping container meant to simulate buildings, training the automation systems to operate even when structures or other vehicles block their line of sight (Muoio). Uber seeks to simulate situations that are more extreme than what may be experienced on real-world roadways to make sure their vehicles as well as their trained drivers are able to handle these situations when they are encountered. Once a driver has been fully trained and a vehicle has passed all of Uber's test requirements, testing is taken to public roads.

Uber's innovations have not come without a price though. On March 18, 2018, one of the first recorded deaths resulting from a crash involving a self-driving vehicle was recorded. Elaine Herzberg was killed in Tempe, Arizona after she was struck by an Uber test vehicle that was in autonomous mode (Griggs and Wakabayashi). This crash was a wakeup call to the industry and a reminder that self-driving technology is still in its early phases and has a long way to go before complete autonomy is possible. Other companies, such as Tesla, have also experienced setbacks to development and testing. In 2016, a man was killed in a crash while using the autopilot features in a Tesla vehicle. Self-driving technology has quite a way to go before it is perfected, and many companies are learning from the mistakes of the past and working towards a safer future.

Similar to Uber, Ford has also developed a test city outside of Ann Arbor, Michigan to test out the autonomous technology that they have been developing over the past decade (Thompson). Like Almono, Ford's MCity simulates an urban environment similar to the real world. Ford is looking to the future and hopes to offer semi-autonomous driving systems in their vehicles as early as 2020. Other major companies that are researching and developing autonomous driving systems include Google and Waymo which was formerly Google's self-driving car test project, and even companies in the food industry such as Pizza Hut, who has partnered with Toyota to create self-driving delivery vehicles. These companies have been researching technology in order to automate vehicles for consumer and commercial use and are not specifically focused on creating self-driving systems for larger vehicles such as semi-trucks.

A number of companies are at the forefront of developing technology that can revolutionize the transportation and logistics industries. Tesla has made some advancements in this industry with the creation of its electric semi-truck. Tesla's semi can drive a maximum of 300 to 500 miles between charges depending on which model is driven and is projected to save more than $200,000 in annual fuel costs (Tesla). The semi is outfitted with an enhanced version of Tesla's autopilot software and achieves Level 3 Automation. Tesla has not yet announced future plans to continue research and development into new fully autonomous models, but their electric semi-truck gives them a foot in the door when it comes to competing with other companies looking to change the industry.

Another company that is developing self-driving technologies is Daimler AG. Daimler is a German automotive corporation that owns a few popular car brands including Mercedes-Benz and Smart and also a few trucking companies such as Freightliner and Western Star (Daimler AG). Daimler has used its Freightliner brand to test and produce what it calls the Freightliner Inspiration. This truck is very much still in the testing phase, but in 2015, Daimler showcased the progress they had made atop the Hoover Dam. Forbes magazine called Daimler's statement as “not only bold, but also symbolic” (Singh). Daimler put itself at the forefront of innovation by unveiling their Freightliner Inspiration and became one of the first companies to enter into the autonomous semi industry. The Freightliner Inspiration is also the very first “licensed autonomous commercial truck to operate on an open public highway” (Freightliner). Daimler and Freightliner continue to research and develop self-driving technology and remain two of the most prominent companies in the industry.

Like Daimler and Freightliner, another company researching and developing self-driving technologies is US based, self-driving technology company, Otto. Since 2016, Otto has been outfitting Volvo semis with self-driving technology and testing and improving their systems. The technology to outfit these semis is incredibly expensive, currently priced around $100,000 from third-party technology companies, and Otto is designing its own system that could cost less than $10,000 (Freedman). Otto’s current system, which is described as a “breadbox-size micro-supercomputer” (Freedman) pulls data from Lidar sensors outfitted on the vehicle, runs the data through advanced computing algorithms, and controls the driving systems using the analyzed data. Lidar stands for Light Detection and Ranging and is a remote sensing method used mainly by scientists to examine and chart the Earth’s surface (NOAA). Due to the expensive costs of Lidar technology, Otto only has seven trucks that operate and test the technology. Even with its limited test subjects and high production costs, Otto is proactively looking for trucking companies to partner with in order to test out their systems in more trucks.

Another major company worth mentioning is Embark, who is working with manufacturing company Peterbilt to retrofit semi-trucks with self-driving technology. Embark’s CEO Alex Rodrigues seeks to partner with the trucking industry rather than challenging it

(Kuang). Since founding Embark in 2016, Rodrigues has already partnered with Peterbilt in order to test Embark's self-driving technology. Embark's trucks have already achieved full automation during test drives on highways and interstates. The major challenge to Embark, and every company developing similar technology, is how to control these trucks once they near cities and urban environments. Embark has partnered with Ryder, who provides logistics and transportation solutions to other companies. In addition to this partnership with Ryder, Embark began delivering shipments for Frigidaire, a consumer home appliance company, to help test their technology.

Embark uses a Ryder truck to deliver the Frigidaire shipments to interstate entry ramps where outfitted Peterbilt trucks pick up the shipment and drive them on to the highway. From the point the truck enters the interstate to the point it exits, its self-driving systems take over. Once the truck needs to exit the highway, a Ryder truck receives the shipment and navigates it to its final destination. Though Embark is still developing ways to navigate urban areas, their partnership with Frigidaire and Ryder allow it to continually test and hone their software.

Embark's automated driving systems have achieved many milestones that other companies have yet to reach. Embark was the first company to drive a truck across the country using automated systems and has even successfully operated in rain and fog and is able to manage highway transfers (Embark). Embark's technology is currently capable of navigating a truck through interstate traffic for many hours without driver takeover. As Embark continues to set milestones once thought to be impossible, they are working with Peterbilt to create a truck with fuel tanks large enough to travel across the United States in roughly 2 days that can be retrofitted with self-driving systems (Etherington). If this innovation becomes a reality, it could have major implications for the logistics industry and for the self-driving technologies industry as a whole.

The Potential Impact of Automation on the Logistics Industry

As companies such as Daimler AG, Embark, and even Uber continue to make strides in the industry of vehicular automation, logistics and transportation companies may choose to adapt certain technologies and begin automating delivery routes. As companies begin to adapt new technologies and changing overarching business strategy to accommodate, it begs the question of how this will affect the industry. At some point in the future, if Level 5 automation becomes a reality and a standard for not only consumer passenger vehicles, but also for commercial semi-trucks, what will the world look like for the licensed truck drivers of today?

According to the United States Bureau of Labor Statistics, there are approximately 1,871,700 truck drivers in the United States who are legally registered to drive heavy and tractor trailer sized trucks (Bureau of Labor Statistics). In addition, there are approximately another 1.5 million drivers of smaller goods transportation vehicles that could one day become self-driving. The demand for drivers is expected to increase by about 6% over the next decade as the demand for goods increases every year, and by the year 2026, there could be as many as 2 million licensed heavy truck drivers in America. But with as automation technology advances, the need for human intervention assisting in the driving process begins to dwindle. Most of companies that are focusing on vehicular automation are in the developing and testing phases of Level 2 and 3 automation. A few companies are doing research into Level 4 automation but are years off from perfecting it and moving on to Level 5. The issue at hand is that, if Level 5 automation is one day achieved, drivers will no longer be needed to assist in the driving process, effectively leaving a subset of the American working class, and many around the world, without a job.

The potential for millions of people around the world to lose their jobs to the automation of the logistics and transportation industry is not an easy pill to swallow, but it is one that comes with financial implications that many corporations may find favorable. If a company has fewer employees than they used to have, their labor costs will in turn decrease. According to the Bureau of Labor Statistics, the median annual wage for truck drivers in the United States is roughly $41,340 (Bureau of Labor Statistics). On average, if a company were to no longer require a certain number of drivers, they could theoretically cut labor costs by $41,340 per driver. *Table 6* shows the amount of money the top 10 largest logistics companies could be spending on labor costs if they pay each driver the median wage. FedEx and the United Parcel service are included in this data.

Table 6: Median Labor Costs per Logistics Company

Logistics Company	Number of Registered Drivers	Estimated Labor Costs Based on a Median Salary of $41,340
Swift Transportation	21,613	$893,481,420
Schneider Intl.	13,600	$562,224,000
JB Hunt	18,331	$757,803,540
Landstar	6,181	$255,522,540
Werner Enterprises	9,795	$405,816,645
Prime	6,775	$280,688,250
US Xpress	6,857	$284,085,510
CRST	3,656	$151,460,080
Crete	5,327	$220,697,910
Knight Transportation	3,848	$159,422,640
FedEx	87,150	$3,610,624,500
United Parcel Service (UPS)	104,832	$4,343,189,760

Sources: Federal Motor Carrier Safety Administration and the Bureau of Labor Statistics

Although these companies do not realistically pay the sums of money displayed above, there are still labor costs to be saved. Companies may find themselves cutting drivers in the future and find themselves seeking engineers and technology specialists to run their automated systems. Demand for engineering and technology jobs related to this field will more than likely skyrocket as major companies begin to adopt self-driving trucks into their fleets. In the long run, if Level 5 automation eliminates the need for human drivers in trucks, companies may see themselves losing more employees than they are bringing in. Truckers very well may be replaced by automotive engineers and technologists in the decades to come, and companies will find themselves budgeting differently for labor costs due to the decrease in their total work force.

As the progression of autonomy continues towards full automation, companies may also find themselves spending a little more on labor and less on transportation costs. Drivers are currently federally mandated to adhere to strict limitations on the number of hours they can drive and are required to rest. Drivers are currently allowed to drive no more than 11 hours at a time and are limited to between 60 and 70 hours in a consecutive 7 to 8 day period (Federal Motor Carrier Safety Administration). In addition, drivers must rest at least 8 hours between driving shifts. With the advancements that are being made, companies that have trucks outfitted with automated systems may find themselves employing two drivers per cab in order to eliminate rest times by working employees in rotating shifts. If two drivers are in the cab at all time, one can monitor the driving systems while the other takes their mandated rest period. Transportation costs may begin to go down as companies can keep trucks moving at all times and the lead time for their deliveries decrease.

Labor and transportation costs may not be the only costs expected to decrease. The cost of fuel consumption is expected to decrease as automated systems are being designed to maximize the fuel efficiencies of trucks. Human drivers are known to be heavy footed on the pedals when it comes to operating vehicles and waste more fuel than automated systems do. Studies were done by independent testing agencies and findings concluded that automated driving systems could save companies 4-7% every year on fuel (Singh). This percentage savings in fuel costs translates to thousands of dollars in savings per truck per year. While companies may be saving money due to work force reduction, the automation of the transportation industry has more positive effects on transportation and fuel costs.

In addition to costs associated with the operations of each company, the automation of trucks will effectively make roadways safer and save companies money on legal settlements that they face each year. The automation of driving systems seeks not only to save money and make driving tasks more efficient, but also seeks to eliminate all injuries and fatalities suffered on roadways. If crashes can be avoided all together, trucking companies no longer have to worry about the time and money spent dealing with tow-away and legal disputes over wrongful injury and death lawsuits. Millions if not billions of dollars can be saved by trucking companies every year, and once Level 5 automation is achieved and perfected, crashes can be nearly eliminated save for crashes caused by natural disasters.

Complete automation of the logistics and transportation industry may be many years away, but companies should know what to expect as the future grows ever closer. Labor costs and employment structures are projected to shift and change in drastic ways as the necessity of a human driver is slowly phased out. As labor structures change, companies may find themselves saving money on transportation costs as well as fuel costs as mandated driving hours no longer apply and maximum fuel efficiency is achieved. If crashes are one day completely eliminated, companies will no longer be faced with expensive lawsuits and the total number of recorded injuries and deaths each year may be completely eliminated. The implications of the automation of the logistics and transportation industries are so much farther reaching than just these confined market spaces. The societal impact of self-driving technology may be the most important implication of all as thousands of lives can be saved every year. No one knows that exact effects that complete automation may have on the logistics and transportation industries and on the world as a whole; only time will tell.

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Appendix A

Appendix A contains charts published by The National Highway Traffic Safety Administration, The European Commission, The European Road Safety Observatory, and The Federal Motor Carrier Safety Administration. Information derived from these charts appears in *Table 1 – Table 4.*

National Highway Traffic Safety Administration:

Large Trucks

Fatalities in Crashes Involving Large Trucks	
2016	4,317
2015	4,094
2014	3,908

Source: FARS

People Injured in Crashes Involving Large Trucks	
2016	N/A†
2015	116,000
2014	111,000

Source: GES

Percent of Fatalities in Crashes Involving Large Trucks by Person Type			
	Truck Occupants	Occupants of Other Vehicles	Nonoccupants
2016	17%	72%	11%
2015	16%	74%	10%
2014	17%	73%	10%

Source: FARS

People Killed or Injured in Crashes Involving Large Trucks, by Person Type and Crash Type, 2007–2016

Year	Truck Occupants by Crash Type						Other People						Total
	Single Vehicle		Multiple Vehicle		Total		Occupant of Other Vehicle		Nonoccupant		Total		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Killed													
2007	502	10%	303	6%	805	17%	3,608	75%	409	8%	4,017	83%	4,822
2008	430	10%	252	6%	682	16%	3,151	74%	412	10%	3,563	84%	4,245
2009	333	10%	166	5%	499	15%	2,558	76%	323	10%	2,881	85%	3,380
2010	339	9%	191	5%	530	14%	2,797	76%	359	10%	3,156	86%	3,686
2011	408	11%	232	6%	640	17%	2,713	72%	428	11%	3,141	83%	3,781
2012	423	11%	274	7%	697	18%	2,857	72%	390	10%	3,247	82%	3,944
2013	431	11%	264	7%	695	17%	2,845	71%	441	11%	3,286	83%	3,981
2014	405	10%	251	6%	656	17%	2,859	73%	393	10%	3,252	83%	3,908
2015	395	10%	270	7%	665	16%	3,015	74%	414	10%	3,429	84%	4,094
2016	460	11%	262	6%	722	17%	3,127	72%	468	11%	3,595	83%	4,317
Injured													
2007	10,000	7%	13,000	12%	23,000	18%	75,000	79%	2,000	2%	78,000	82%	101,000
2008	10,000	8%	13,000	12%	23,000	20%	64,000	78%	3,000	3%	67,000	80%	90,000
2009	7,000	7%	9,000	12%	17,000	19%	56,000	79%	1,000	2%	57,000	81%	74,000
2010	9,000	6%	11,000	12%	20,000	19%	58,000	78%	2,000	3%	60,000	81%	80,000
2011	7,000	6%	15,000	13%	23,000	19%	64,000	79%	2,000	2%	65,000	81%	88,000
2012	9,000	6%	17,000	13%	25,000	19%	76,000	78%	3,000	3%	79,000	81%	104,000
2013	9,000	8%	15,000	16%	24,000	25%	69,000	72%	2,000	3%	71,000	75%	95,000
2014	10,000	9%	17,000	14%	27,000	23%	82,000	74%	2,000	3%	84,000	77%	111,000
2015	10,000	8%	19,000	15%	30,000	24%	84,000	73%	3,000	4%	86,000	76%	116,000
2016	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Large-Truck Involvement in Fatal and Injury Crashes, and Involvement Rates, 2007–2016

Year	Number of Large Trucks Involved in Fatal Crashes	Number of Large Trucks Registered	Involvement Rate per 100,000 Registered Large Trucks	Large-Truck Miles Traveled (millions)	Involvement Rate per 100 million Large-Truck Miles Traveled
2007	4,633	10,752,019	43.09	304,178	1.52
2008	4,089	10,873,275	37.61	310,680	1.32
2009	3,211	10,973,214	29.26	288,306	1.11
2010	3,494	10,770,054	32.44	286,527	1.22
2011	3,633	10,270,693	35.37	267,594	1.36
2012	3,825	10,659,380	35.88	269,207	1.42
2013	3,921	10,597,356	37.00	275,017	1.43
2014	3,749	10,905,956	34.38	279,132	1.34
2015	4,074	11,203,184	36.36	279,844	1.46
2016	4,213	11,498,561	36.64	287,895	1.46
Year	Number of Large Trucks Involved in Injury Crashes	Number of Large Trucks Registered	Involvement Rate per 100,000 Registered Large Trucks	Large-Truck Miles Traveled (millions)	Involvement Rate per 100 million Large-Truck Miles Traveled
2007	76,000	10,752,019	705	304,178	25
2008	66,000	10,873,275	608	310,680	21
2009	53,000	10,973,214	487	288,306	19
2010	58,000	10,770,054	541	286,527	20
2011	63,000	10,270,693	609	267,594	23
2012	77,000	10,659,380	719	269,207	28
2013	73,000	10,597,356	690	275,017	27
2014	88,000	10,905,956	811	279,132	32
2015	87,000	11,203,184	779	279,844	31
2016	N/A	11,498,561	N/A	287,895	N/A

People Killed or Injured in Crashes Involving Large Trucks, by Person Type and Crash Type, 2006–2015

Year	Truck Occupants by Crash Type						Other People						Total
	Single Vehicle		Multiple Vehicle		Total		Occupant of Other Vehicle		Nonoccupant		Total		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Killed													
2006	500	10%	305	6%	805	16%	3,797	76%	425	8%	4,222	84%	5,027
2007	502	10%	303	6%	805	17%	3,608	75%	409	8%	4,017	83%	4,822
2008	430	10%	252	6%	682	16%	3,151	74%	412	10%	3,563	84%	4,245
2009	333	10%	166	5%	499	15%	2,558	76%	323	10%	2,881	85%	3,380
2010	339	9%	191	5%	530	14%	2,797	76%	359	10%	3,156	86%	3,686
2011	408	11%	232	6%	640	17%	2,713	72%	428	11%	3,141	83%	3,781
2012	423	11%	274	7%	697	18%	2,857	72%	390	10%	3,247	82%	3,944
2013	431	11%	264	7%	695	17%	2,845	71%	441	11%	3,286	83%	3,981
2014	405	10%	251	6%	656	17%	2,859	73%	393	10%	3,252	83%	3,908
2015	398	10%	269	7%	667	16%	2,990	74%	410	10%	3,400	84%	4,067
Injured													
2006	11,000	7%	12,000	13%	23,000	20%	81,000	78%	2,000	2%	83,000	80%	106,000
2007	10,000	7%	13,000	12%	23,000	18%	75,000	79%	2,000	2%	78,000	82%	101,000
2008	10,000	8%	13,000	12%	23,000	20%	64,000	78%	3,000	3%	67,000	80%	90,000
2009	7,000	7%	9,000	12%	17,000	19%	56,000	79%	1,000	2%	57,000	81%	74,000
2010	9,000	6%	11,000	12%	20,000	19%	58,000	78%	2,000	3%	60,000	81%	80,000
2011	7,000	6%	15,000	13%	23,000	19%	64,000	79%	2,000	2%	65,000	81%	88,000
2012	9,000	6%	17,000	13%	25,000	19%	76,000	78%	3,000	3%	79,000	81%	104,000
2013	9,000	8%	15,000	16%	24,000	25%	69,000	72%	2,000	3%	71,000	75%	95,000
2014	10,000	9%	17,000	14%	27,000	23%	82,000	74%	2,000	3%	84,000	77%	111,000
2015	10,000	8%	19,000	15%	30,000	24%	84,000	73%	3,000	4%	86,000	76%	116,000

Large-Truck Involvement in Fatal and Injury Crashes and Involvement Rates, 2006–2015

Year	Number of Large Trucks Involved in Fatal Crashes	Number of Large Trucks Registered	Involvement Rate per 100,000 Registered Large Trucks	Large-Truck Miles Traveled (millions)	Involvement Rate per 100 million Large-Truck Miles Traveled
2006	4,766	8,819,007	54.04	222,513	2.14
2007	4,633	10,752,019	43.09	304,178	1.52
2008	4,089	10,873,275	37.61	310,680	1.32
2009	3,211	10,973,214	29.26	288,306	1.11
2010	3,494	10,770,054	32.44	286,527	1.22
2011	3,633	10,270,693	35.37	267,594	1.36
2012	3,825	10,659,380	35.88	269,207	1.42
2013	3,921	10,597,356	37.00	275,017	1.43
2014	3,749	10,905,956	34.38	279,132	1.34
2015	4,050	11,203,184	36.15	279,844	1.45
Year	**Number of Large Trucks Involved in Injury Crashes**	**Number of Large Trucks Registered**	**Involvement Rate per 100,000 Registered Large Trucks**	**Large-Truck Miles Traveled (millions)**	**Involvement Rate per 100 million Large-Truck Miles Traveled**
2006	80,000	8,819,007	911	222,513	36
2007	76,000	10,752,019	705	304,178	25
2008	66,000	10,873,275	608	310,680	21
2009	53,000	10,973,214	487	288,306	19
2010	58,000	10,770,054	541	286,527	20
2011	63,000	10,270,693	609	267,594	23
2012	77,000	10,659,380	719	269,207	28
2013	73,000	10,597,356	690	275,017	27
2014	88,000	10,905,956	811	279,132	32
2015	87,000	11,203,184	779	279,844	31

The European Commission and The European Road Safety Observatory:

	Passenger cars	Goods vehicles	Buses & coaches	Bicycles	Mopeds	Motocycles	Pedestrians	Other	Total
European Union (*)	**11 362**	**1 207**	**150**	**1 990**	**747**	**3 804**	**5 568**	**575**	**25 401**
Belgium	340	47	5	73	13	102	99	44	723
Bulgaria	:	:	:	:	:	:	:	:	:
Czech Republic	308	34	2	74	6	66	162	2	654
Denmark	79	18	0	33	11	15	34	1	191
Germany	1 588	148	11	354	73	568	561	36	3 339
Estonia	41	2	2	0	0	0	23	13	81
Ireland	107	14	0	5	0	26	31	5	188
Greece	347	45	2	15	25	271	151	23	879
Spain	716	112	11	70	56	302	371	42	1 680
France	1 615	189	7	147	159	658	465	28	3 268
Croatia	195	4	1	23	14	49	69	13	368
Italy	1 491	145	48	251	125	724	551	62	3 395
Cyprus	16	3	0	2	0	15	8	0	44
Latvia	71	8	1	13	3	10	70	3	179
Lithuania	108	7	1	18	4	15	96	7	256
Luxembourg	30	2	0	0	0	8	5	0	45
Hungary	254	30	6	68	24	58	147	4	591
Malta	:	:	:	:	:	:	:	:	:
Netherlands	180	22	0	112	41	29	51	41	476
Austria	194	21	0	52	15	87	82	4	455
Poland	1 448	90	18	306	62	253	1 140	40	3 357
Portugal	214	79	11	29	51	78	144	31	637
Romania	721	79	8	161	39	52	726	75	1 861
Slovenia	40	6	0	16	4	17	20	22	125
Slovakia	148	16	2	21	10	0	81	43	321
Finland	152	15	1	20	5	24	34	7	258
Sweden	144	10	1	14	3	40	42	6	260
United Kingdom	815	61	12	113	4	337	405	23	1 770
Iceland	11	1	0	0	0	1	1	1	15
Liechtenstein	:	:	:	:	:	:	:	:	2
Norway	105	20	5	10	3	21	18	5	187
Switzerland	103	6	0	21	8	55	69	7	269

(:) Data not available

(*) EU aggregate excludes Bulgaria and Malta for which no detail could be supplied.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
BE	161	133	156	122	117	111	116	111	100	130
BG	-	-	-	200	179	-	-	-	-	-
CZ	240	215	220	169	163	175	159	139	124	138
DK	79	49	66	62	35	36	33	29	32	24
DE	684	719	687	625	536	534	564	812	759	601
EE	50	37	35	32	21	3	6	7	7	4
IE	51	57	40	44	22	13	20	12	22	-
EL	158	167	141	138	113	127	91	58	74	73
ES	714	659	528	452	353	333	297	245	217	262
FR	726	683	658	596	504	552	576	485	463	474
HR	-	-	104	119	77	44	37	29	41	39
IT	1.174	1.140	1.017	977	785	358	337	280	267	272
CY	0	1	1	0	0	1	-	1	3	0
LV	81	81	97	46	38	41	21	36	37	38
LT	-	-	-	-	-	-	-	-	42	33
LU	4	7	7	2	2	9	3	3	8	5
HU	251	239	218	173	118	144	101	118	106	112
MT	0	1	0	1	0	1	-	-	-	-
NL	103	129	123	107	95	80	76	73	83	71
AT	126	120	89	111	81	97	70	77	50	51
PL	1.425	1.374	1.246	1.155	952	947	1.018	816	748	708
PT	163	130	145	112	120	95	107	77	80	78
RO	297	263	271	296	252	191	169	169	139	147
SI	21	4	20	7	12	7	6	3	7	-
SK	134	122	144	141	69	106	-	-	34	-
FI	92	82	97	106	70	92	85	98	70	59
SE	61	83	92	72	45	41	46	41	30	55
UK	510	434	449	380	287	269	265	278	264	279
EU	**7.609**	**7.233**	**6.851**	**6.245**	**5.046**	**4.586**	**4.490**	**4.211**	**3.945**	**3.863**
Yearly Change		**-4,9%**	**-5,3%**	**-8,8%**	**-19,2%**	**-9,1%**	**-2,1%**	**-6,2%**	**-6,3%**	**-2,1%**
IS	3	2	4	4	3	1	2	1	1	4
NO	49	74	59	53	56	71	55	35	48	33
CH	46	40	34	39	45	29	33	35	31	25

Federal Motor Carrier Safety Administration:

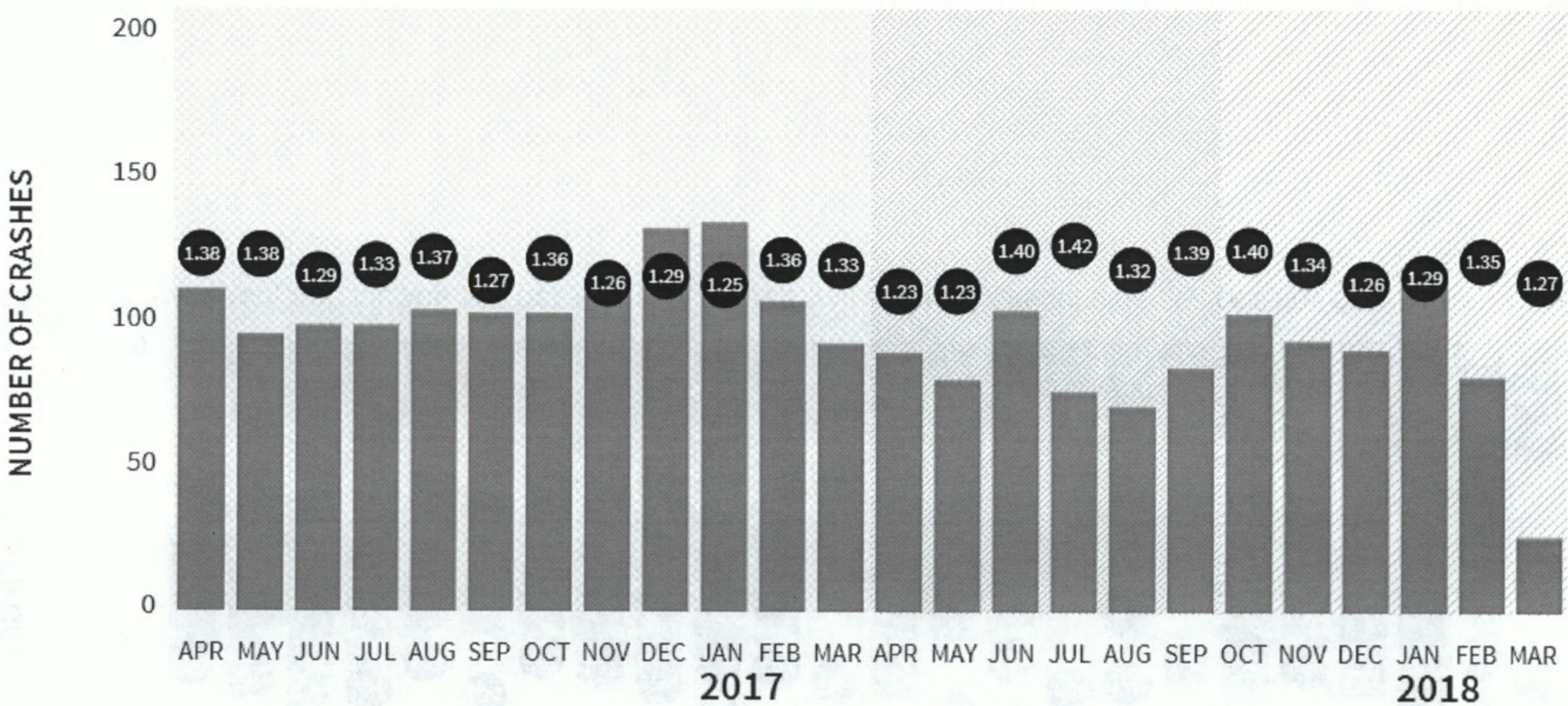
Truck Type Involved in Crash	Injury Severity	Annual Number of Victims*	Medical Costs	Emerg-ency Services	Property Damage	Lost Produc-tivity from Delays	Total Lost Produc-tivity	Monetize d QALYs Based on VSL $3 Million	Total Cost per Victim	QALYs
Straight truck, no trailer	O – No injury	140,783	117	42	1,483	1,702	2,576	542	4,759	0.0045
	C – Possible injury	21,126	5,938	152	2,891	3,903	19,217	22,628	50,828	0.1894
	B – Non-incapacitating injury	6,998	28,981	185	4,685	4,974	65,062	82,686	181,598	0.692
	A – Incapacitating injury	3,526	38,655	281	6,118	4,914	111,133	143,365	299,551	1.1998
	K – Killed	1,098	30,916	989	14,919	6,143	916,141	2,083,859	3,046,823	17.44
	U – Injury, severity unknown	2,059	4,116	190	3,350	3,737	9,434	10,420	27,509	0.087
	Unknown if injured	9,008	918	114	2,303	3,454	5,528	2,570	11,433	0.022
Straight truck w/ trailer	O – No injury	13,803	437	42	2,097	1,795	2,626	760	5,963	0.0064
	C – Possible injury	3,324	7,680	185	5,676	4,150	22,874	26,895	63,310	0.2251
	B – Non-incapacitating injury	765	11,164	138	6,956	4,507	57,376	56,141	131,774	0.4698
	A – Incapacitating injury	820	30,880	319	8,477	4,768	115,872	113,361	268,910	0.9487
	K – Killed	162	30,916	989	21,258	6,143	916,141	2,083,859	3,053,163	17.44
	U – Injury, severity unknown	306	6,561	214	5,900	2,924	50,954	31,216	94,845	0.2612
	Unknown if injured	1,282	956	83	3,004	1,878	4,081	3,851	11,975	0.0322
Bobtail	O – No injury	10,706	409	43	2,015	2,223	3,164	897	6,528	0.0075
	C – Possible injury	2,690	7,389	155	3,894	4,589	21,649	22,619	55,707	0.1893
	B – Non-incapacitating injury	405	18,822	283	6,402	5,042	67,831	117,932	211,270	0.987
	A – Incapacitating injury	1,192	29,815	396	8,389	5,042	109,289	206,195	354,083	1.7257
	K – Killed	38	30,916	989	20,403	6,143	916,141	2,083,859	3,052,308	17.44
	U – Injury, severity unknown	344	373	163	4,496	1,937	2,710	931	8,672	0.0078
	Unknown if injured	876	1,050	75	3,166	1,923	3,626	3,047	10,964	0.0255
Truck-Tractor, 1 trailer	O – No injury	215,614	485	43	2,313	1,794	2,828	781	6,451	0.0065
	C – Possible injury	29,283	8,831	187	6,274	4,109	23,473	32,742	71,508	0.274
	B – Non-incapacitating injury	27,240	13,347	150	7,708	4,477	46,655	52,854	120,713	0.4423
	A – Incapacitating injury	14,529	33,931	264	9,314	4,740	104,494	134,262	282,264	1.1236
	K – Killed	3,296	30,916	989	23,509	6,143	916,141	2,083,859	3,055,413	17.44

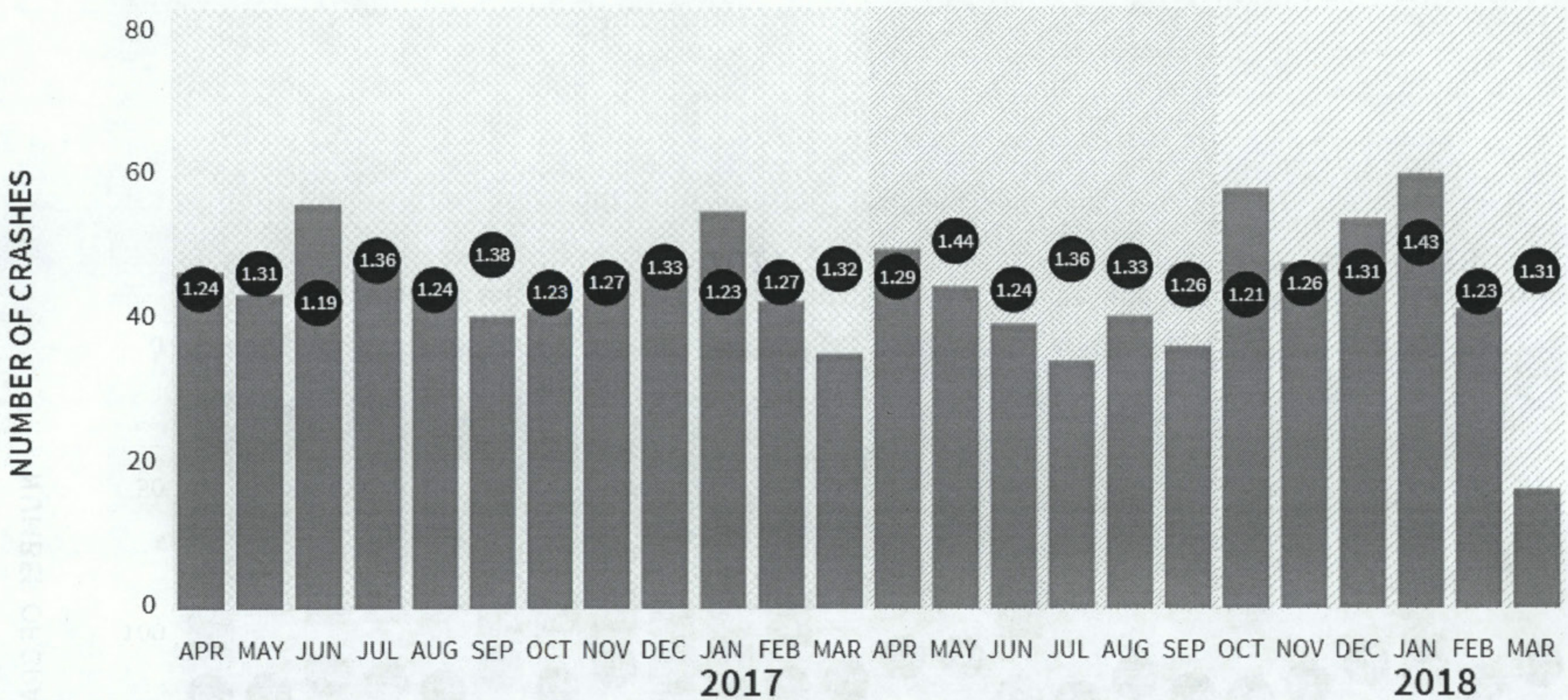
Truck Type Involved in Crash	Maximum Injury Severity	Annual Number of Victims*	Avg. No. People Involved in Crash	Medical Costs	Emer-gency Services	Property Damage	Lost Produc-tivity from Delays	Total Lost Produc-tivity	Monetize d QALYs Based on VSL $3 Million	Total Cost per Crash	QALYs
Straight truck, no trailer	O – No injury	116,476	1.24	253	132	4,730	5,417	7,431	740	13,286	0.0062
	C – Possible injury	17,491	1.59	8,396	399	8,404	10,656	24,673	20,493	62,364	0.1715
	B – Non-incapacitating injury	4,665	1.51	15,903	203	7,482	8,337	86,964	87,673	198,225	0.7337
	A – Incapacitating injury	2,612	1.59	84,052	603	11,139	10,411	223,154	321,546	640,494	2.691
	K – Killed	1,016	1.61	48,893	1,149	19,676	11,409	962,119	2,104,573	3,136,409	17.6134
	U – Injury, severity unknown	527	1.40	5,398	377	8,232	9,083	18,804	11,496	44,307	0.0962
	Unknown if injured	7,245	1.34	1,286	234	5,632	7,735	11,786	3,176	22,114	0.0266
Straight truck w/ trailer	O – No injury	12,502	1.21	1,272	140	6,740	5,763	7,870	1,273	17,295	0.0107
	C – Possible injury	1,359	1.59	13,681	475	14,852	11,384	28,075	34,447	91,530	0.2883
	B – Non-incapacitating injury	517	1.49	14,110	279	17,084	12,706	96,369	92,597	220,440	0.775
	A – Incapacitating injury		2.10	34,573	507	16,138	10,772	181,926	130,292	363,436	1.0904
	K – Killed	162	1.73	58,694	1,089	25,788	10,028	932,569	2,124,691	3,142,831	17.7817
	U – Injury, severity unknown	20	2.25	2,230	375	18,028	11,502	19,347	6,011	45,990	0.0503
	Unknown if injured	1,277	1.15	2,053	186	7,623	5,664	9,419	4,116	23,396	0.0344
Bobtail	O – No injury	9,843	1.25	984	132	6,332	6,892	9,598	2,042	19,089	0.0171
	C – Possible injury	1,269	1.59	8,015	363	11,459	13,246	27,778	16,709	64,324	0.1398
	B – Non-incapacitating injury	266	1.60	10,835	197	9,936	9,273	96,472	56,066	173,507	0.4692
	A – Incapacitating injury	858	1.58	36,300	500	9,985	8,127	117,368	217,195	381,348	1.8177
	K – Killed	37	1.45	39,249	1,126	26,663	12,430	971,748	2,133,782	3,172,568	17.8578
	U – Injury, severity unknown	59	1.04	1,414	278	8,828	6,269	9,398	3,005	22,923	0.0251
	Unknown if injured	786	1.14	1,586	158	7,484	5,915	9,402	3,770	22,401	0.0316
Truck-Tractor, 1 trailer	O – No injury	179,181	1.12	1,119	120	6,493	5,024	6,867	1,151	15,749	0.0096
	C – Possible injury	19,461	1.53	13,010	460	15,410	10,506	26,590	35,489	90,959	0.297
	B – Non-incapacitating injury	17,688	1.49	15,828	205	12,832	7,909	75,649	67,197	171,710	0.5624
	A – Incapacitating injury	10,843	1.57	53,003	510	16,329	9,528	152,532	215,471	437,845	1.8033
	K – Killed	2,825	1.58	81,335	1,495	39,366	14,941	1,200,333	2,511,192	3,833,721	21.0164

Appendix B

Appendix B contains bar charts from which *Table 5* was derived. These bar charts depict the number of crashes reported from the 10 largest transportation companies in the United States with the addition of FedEx and UPS. These charts also depict the average severity weight of each crash. All of the charts were published by The Federal Motor Carrier Safety Administration.

Swift Transportation:




NUMBER OF CRASHES
80
60
40
20
0
1.24 1.31 1.19 1.36 1.24 1.38 1.23 1.27 1.33 1.23 1.27 1.32 1.29 1.44 1.24 1.36 1.33 1.26 1.21 1.26 1.31 1.43 1.23 1.31
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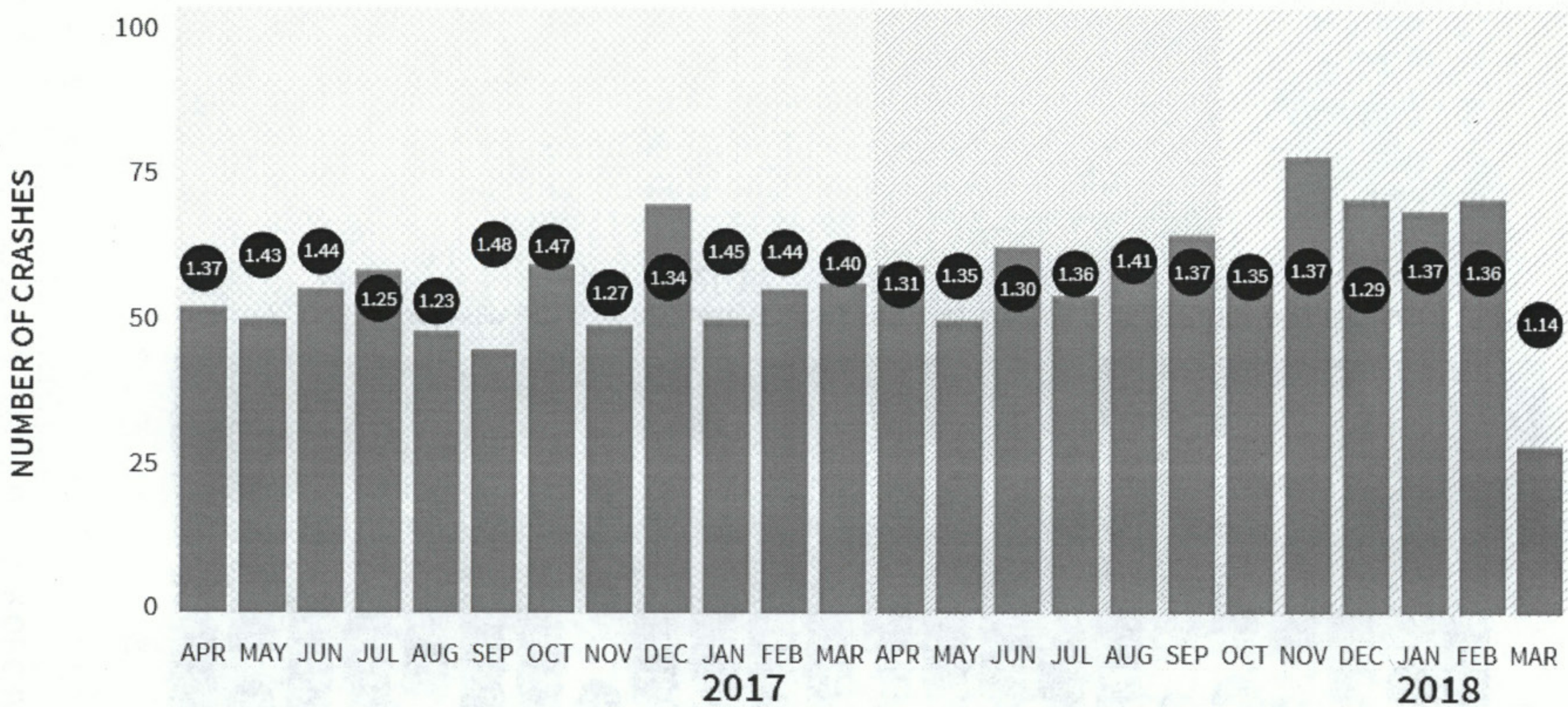
2017
2018

JB Hunt:



100
75
50
25
0
NUMBER OF CRASHES
1.37
1.43
1.44
1.25
1.23
1.48
1.47
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1.34
1.45
1.44
1.40
1.31
1.35
1.30
1.36
1.41
1.37
1.35
1.37
1.29
1.37
1.36
1.14
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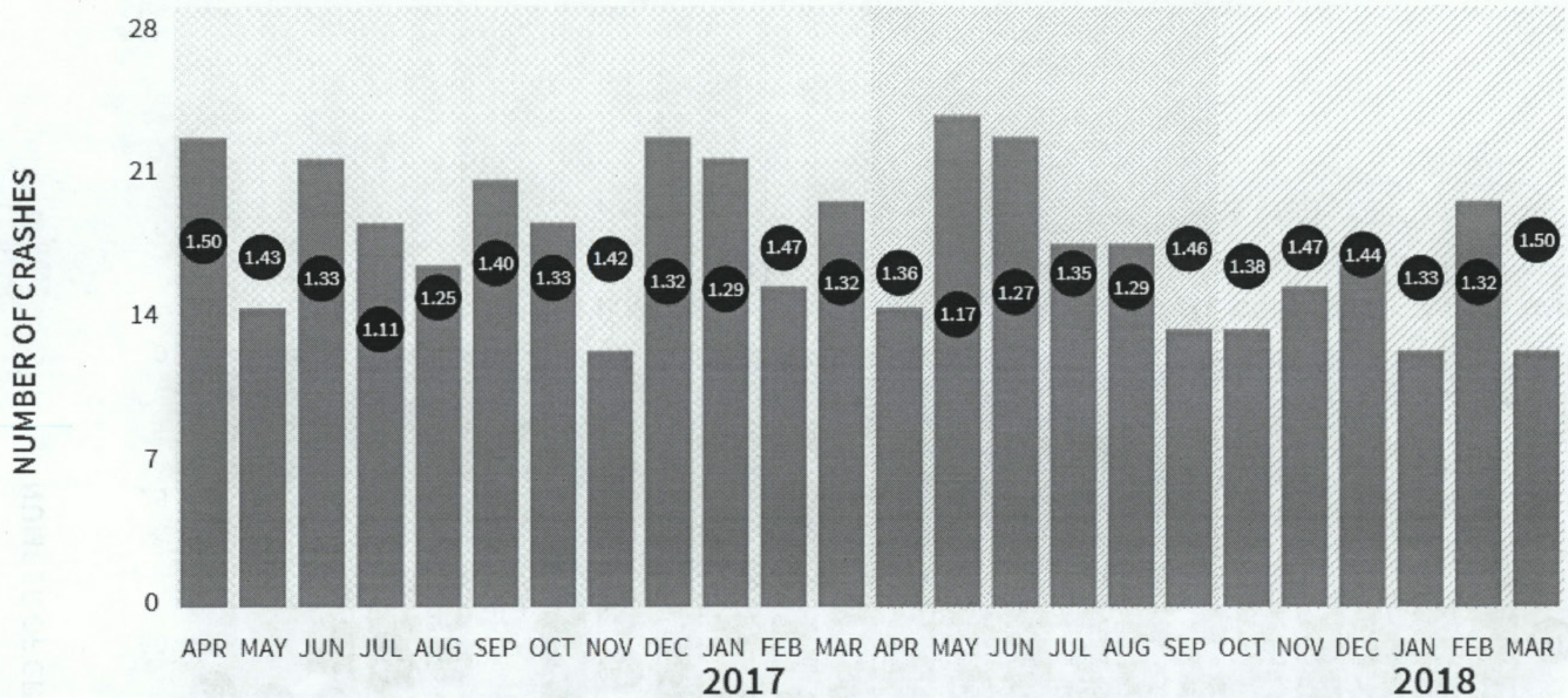
2017
2018

Landstar:


NUMBER OF CRASHES
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14
7
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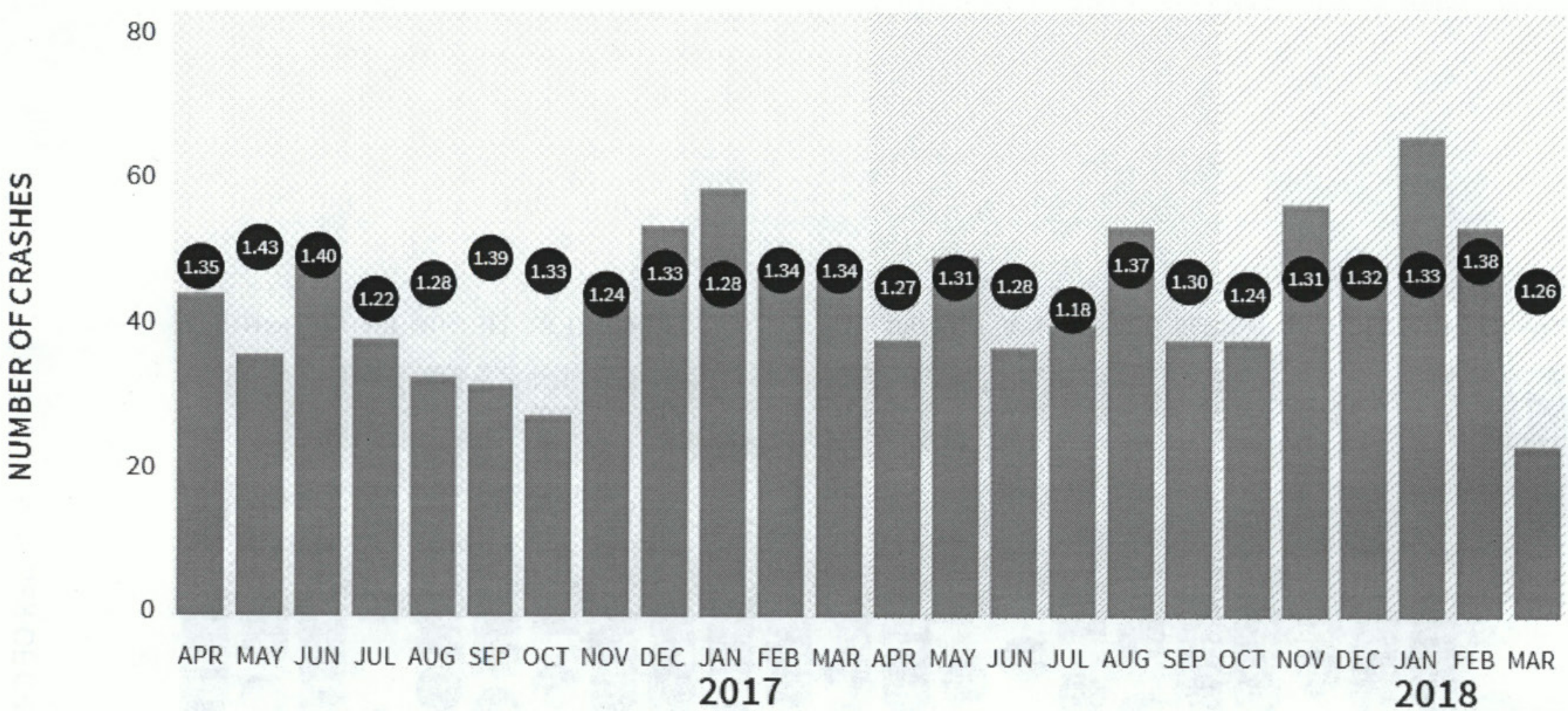
1.50
1.43
1.33
1.11
1.25
1.40
1.33
1.42
1.32
1.29
1.47
1.32
1.36
1.17
1.27
1.35
1.29
1.46
1.38
1.47
1.44
1.33
1.32
1.50
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
2017
2018

Werner Enterprises:



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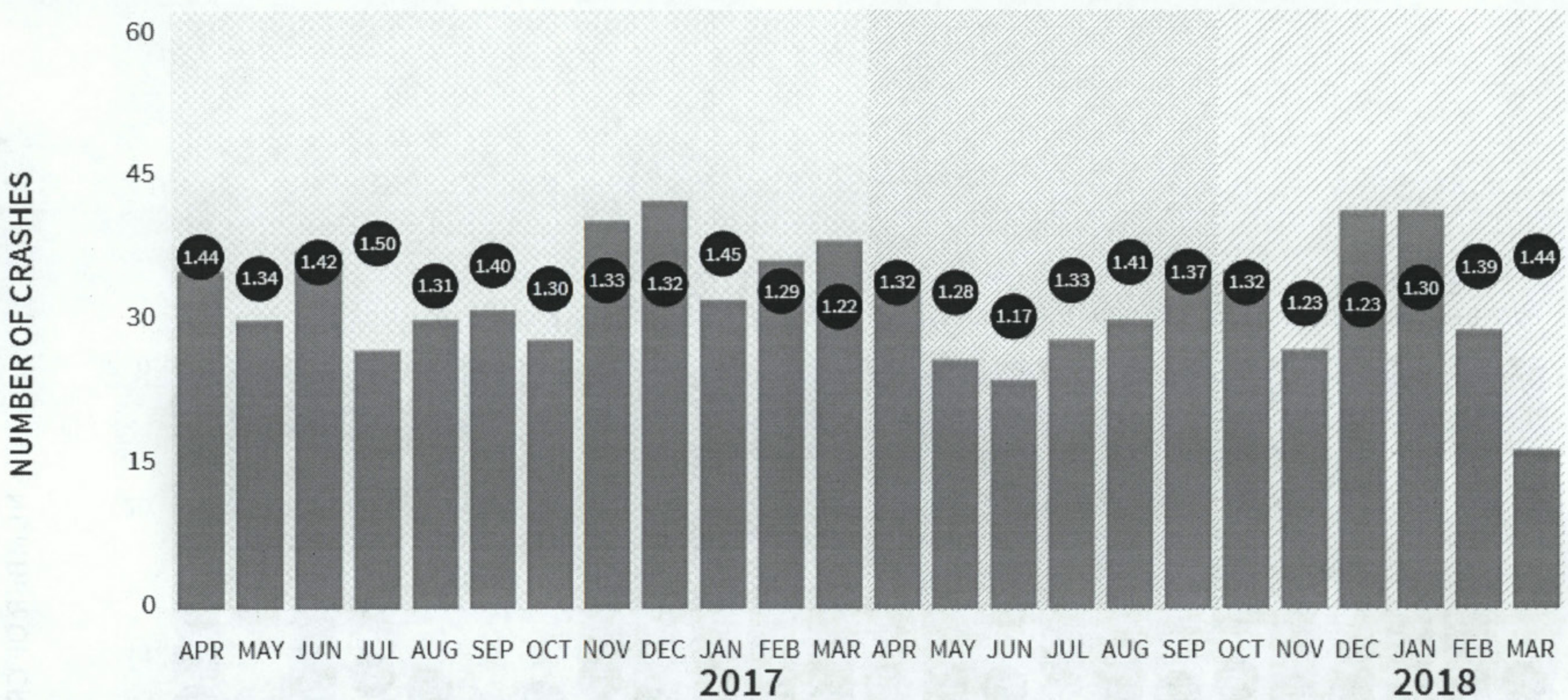

60
45
30
15
0
NUMBER OF CRASHES
1.44
1.34
1.42
1.50
1.31
1.40
1.30
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1.32
1.45
1.29
1.22
1.32
1.28
1.17
1.33
1.41
1.37
1.32
1.23
1.23
1.30
1.39
1.44
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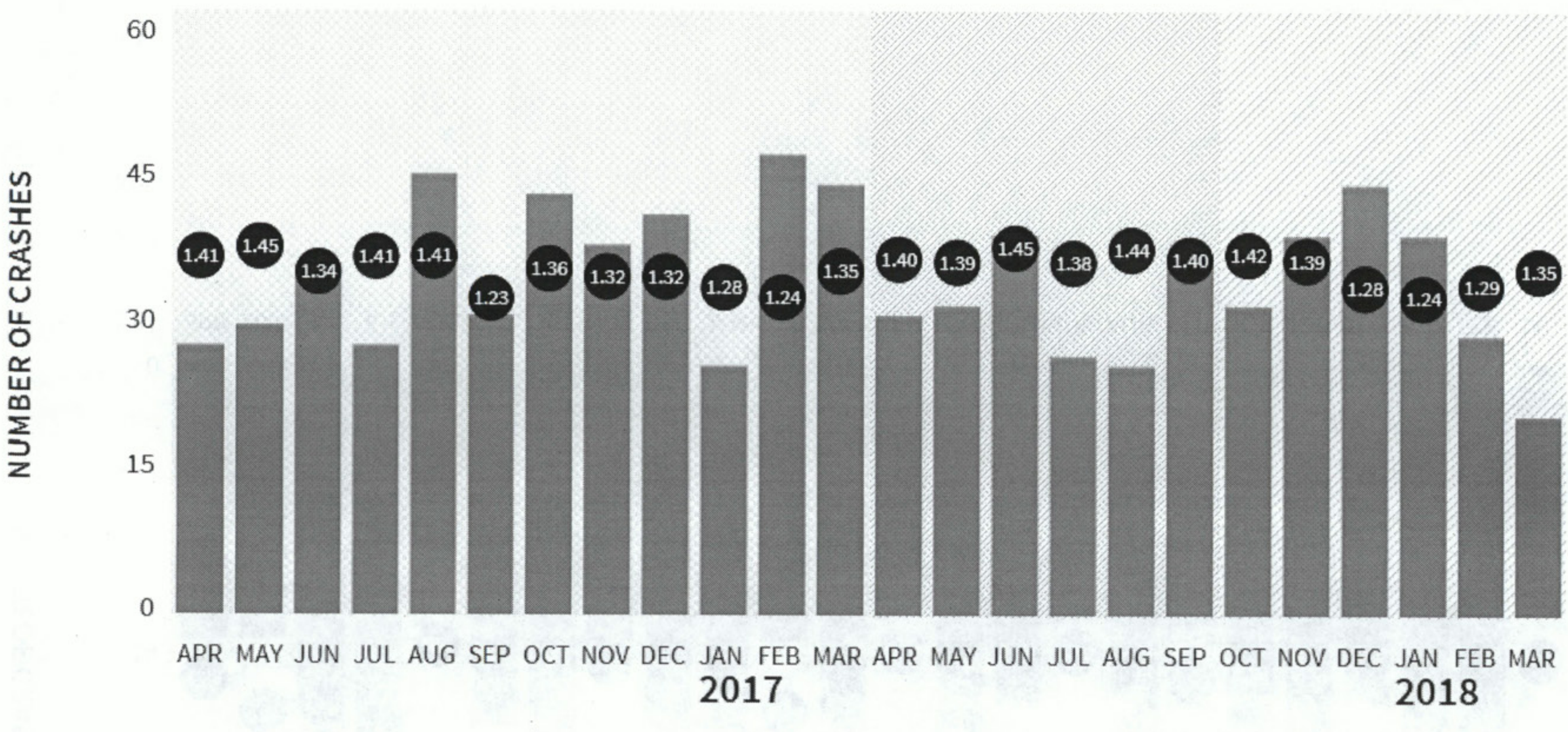
2017
2018

US Xpress:



NUMBER OF CRASHES
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30
15
0
1.41
1.45
1.34
1.41
1.41
1.23
1.36
1.32
1.32
1.28
1.24
1.35
1.40
1.39
1.45
1.38
1.44
1.40
1.42
1.39
1.28
1.24
1.29
1.35
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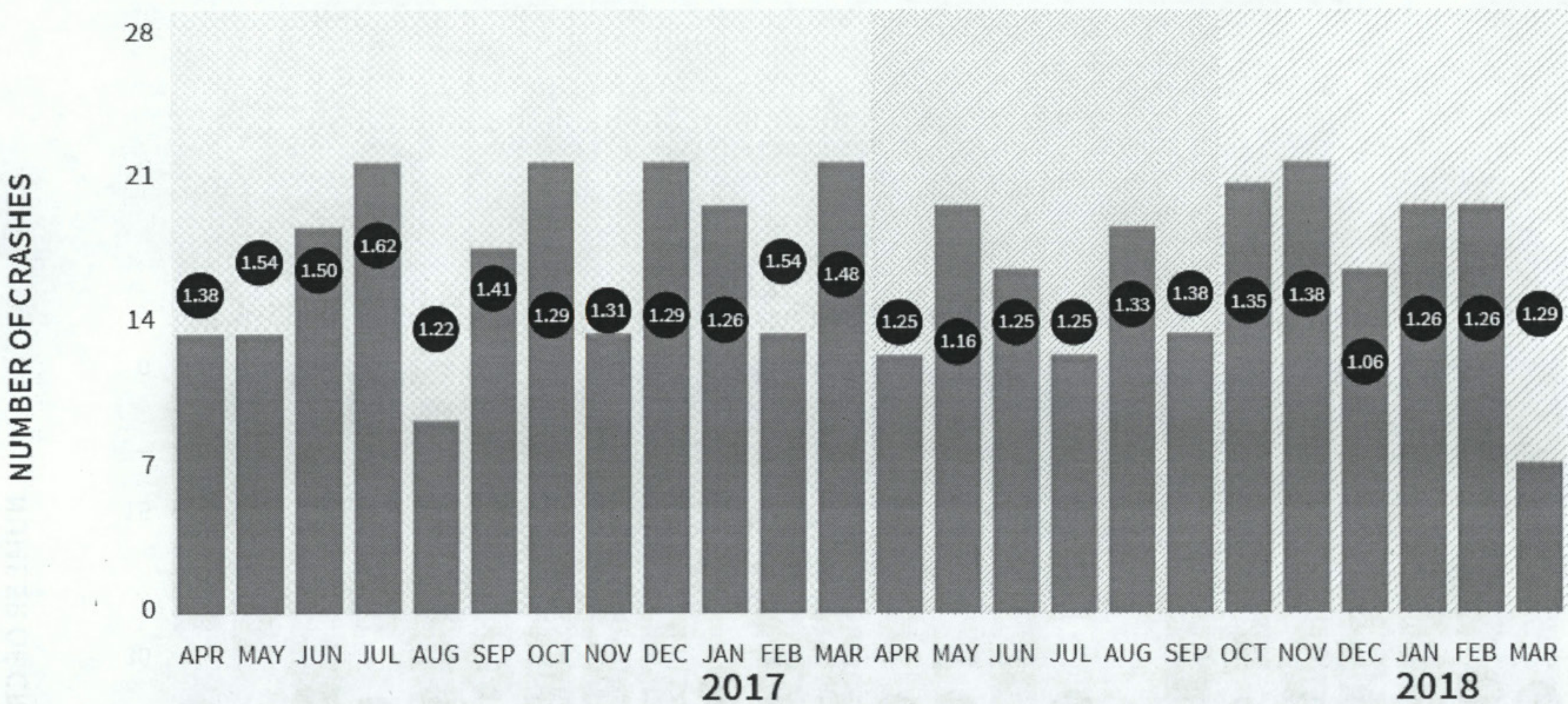
2017
2018

CRST:



NUMBER OF CRASHES
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7
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1.50
1.62
1.22
1.41
1.29
1.31
1.29
1.26
1.54
1.48
1.25
1.16
1.25
1.25
1.33
1.38
1.35
1.38
1.06
1.26
1.26
1.29
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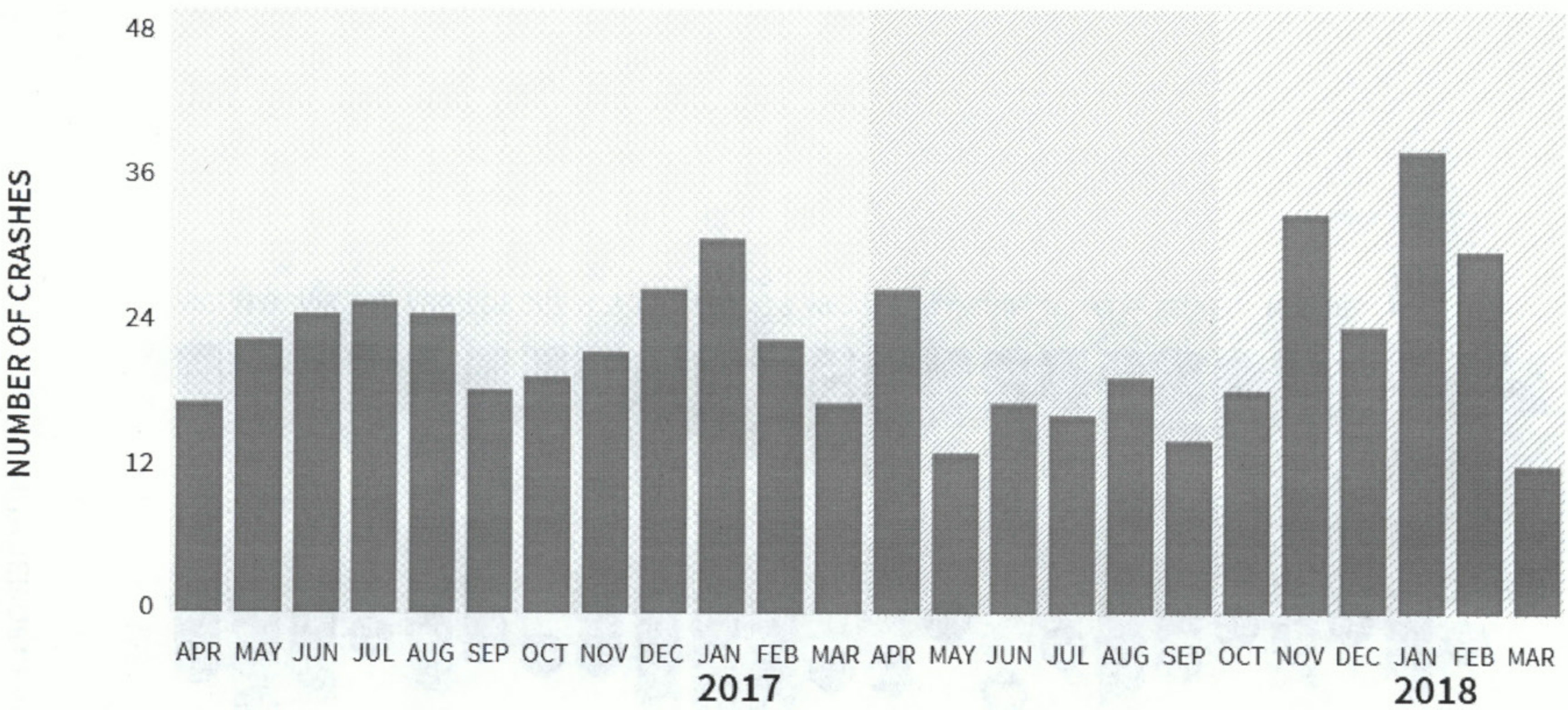
2017
2018

Crete:



NUMBER OF CRASHES
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36
24
12
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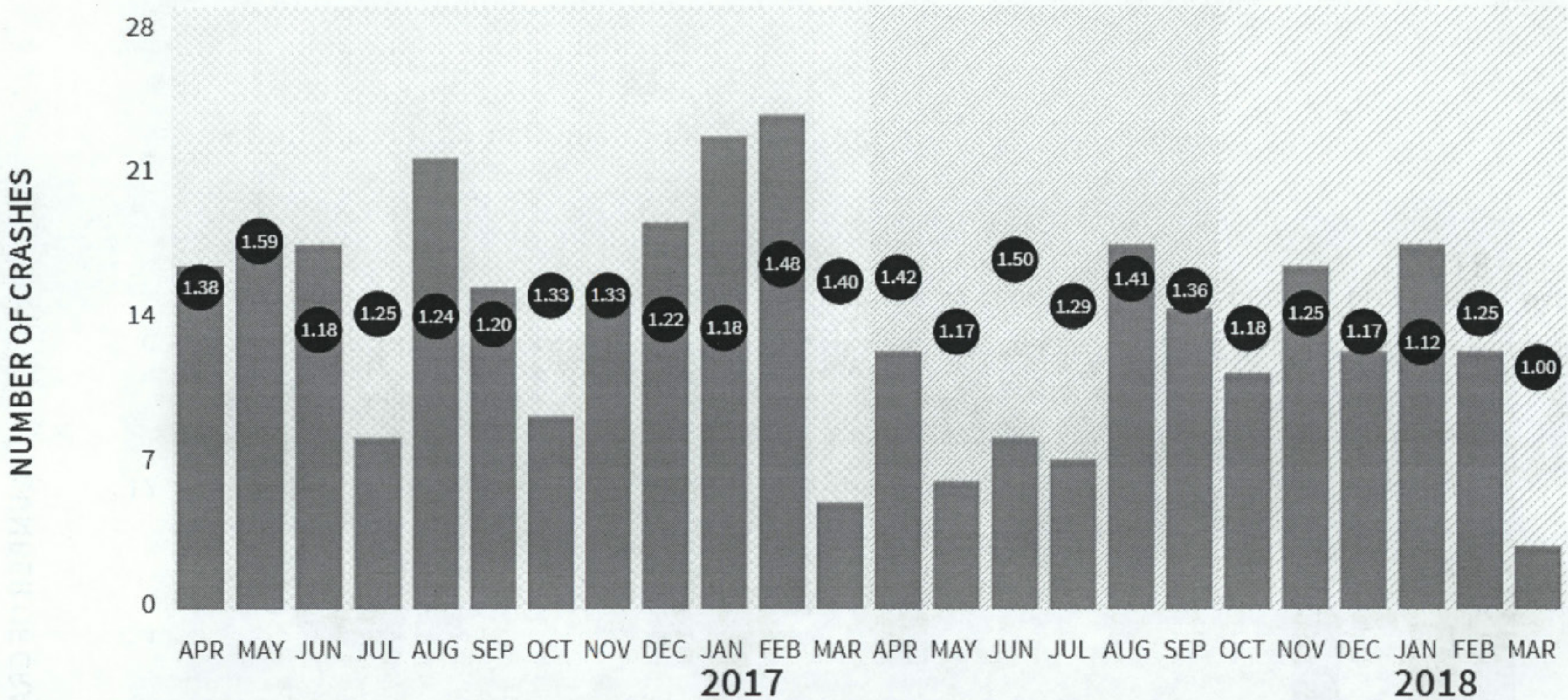
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
2017
2018

Knight Transportation:



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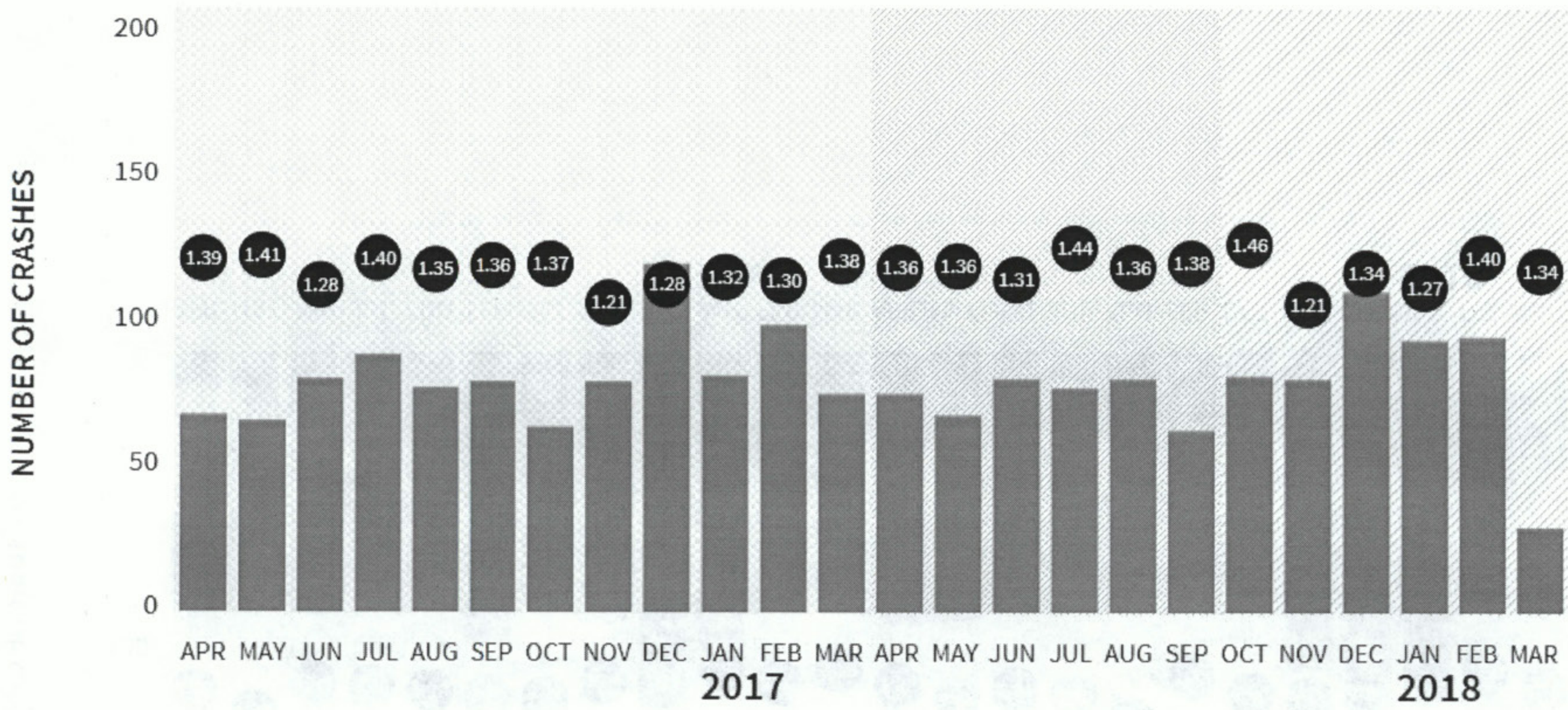

NUMBER OF CRASHES
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150
100
50
0
1.39
1.41
1.28
1.40
1.35
1.36
1.37
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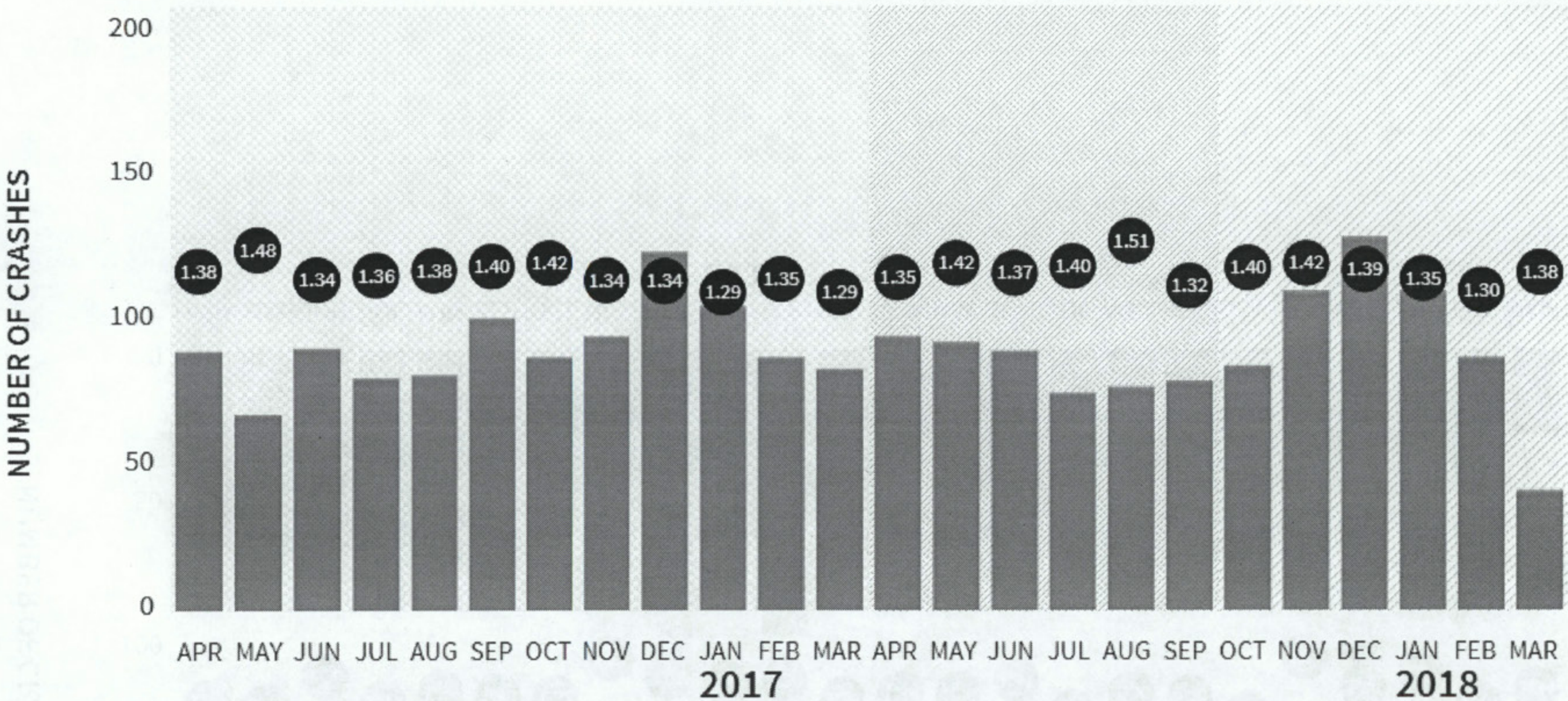
1.28
1.32
1.30
1.38
1.36
1.36
1.31
1.44
1.36
1.38
1.46
1.21
1.34
1.27
1.40
1.34
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
2017
2018

UPS:



NUMBER OF CRASHES
200
150
100
50
0
1.38
1.48
1.34
1.36
1.38
1.40
1.42
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1.34
1.29
1.35
1.29
1.35
1.42
1.37
1.40
1.51
1.32
1.40
1.42
1.39
1.35
1.30
1.38
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
2017
2018